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TITLE: Methods for forming self-planarized

dielectric layer for

shallow trench isolation

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Abstract Text - ABTX (1):

A method for depositing a trench oxide filling layer (300) on a trenched

substrate (224) utilizes the surface sensitivity of dielectric materials such

as <u>O.sub.3 /TEOS</u>. Such materials have different desposition rates on

differently constituted surfaces at different levels on the trenched substrate

(224) so that the surface profile of the deposited layer (300) is substantially

self-planarized. Depositing the dielectric material on a silicon trench (228)

produces a high quality filling layer, and cleaning the trench (228) prior to

desposition can increase the quality. After desposition, an oxidizing anneal

can be performed to grow a thermal oxide (308) at the trench surfaces and

densify the dielectric material. A chemical mechanical polish can be used to

remove the excess oxide material above an etch stop layer (226) of the

substrate (224) which can be formed of LPCVD nitride or CVD anti-reflective coating.

Brief Summary Text - BSTX (8):

A number of procedures are known for depositing dielectric layers such as

the <u>gap</u>-fill dielectric 128 for the trench oxide filling layer in the example

shown in FIG. 1e. One type of process employs O.sub.3

(ozone) and TEOS

(tetraethylorthosilicate) for depositing a dielectric film such as silicate

glass. Such films deposited are commonly referred to as "O.sub.3 /TEOS films".

O.sub.3 /TEOS processes have a surface sensitivity which
increases as the

O.sub.3 /TEOS ratio increases. Due to the surface
sensitivity, the dielectric

deposition rate varies in accordance with the properties of the material of the underlying layer.

Brief Summary Text - BSTX (9):

It is known to minimize the surface sensitivity by depositing a surface

insensitive barrier layer prior to the 0.sub.3 /TEOS film deposition. For

instance, one known process involves a plasma-enhanced TEOS (PETEOS)

deposition, followed by a surface treatment and then a thin cap TEOS layer.

This process undesirably requires additional process steps.

Another known

method is to lower the surface sensitivity by decreasing the **0.sub.3** /**TEOS**

ratio. However, lowering the O.sub.3 /TEOS ratio tends to undesirably result

in a more porous dielectric film. This is particularly problematic when the

dielectric film is used for isolation purposes. One way to address this

concern has been to raise the process temperature to above about 500.degree.

C., but raising the process temperature is often undesirable. Alternatively,

an additional anneal process after the deposition of the trench oxide filling

layer and sandwiching PETEOS layers has been used to densify the trench oxide

filling layer. This method, however, suffers from the need to perform an extra step.

Brief Summary Text - BSTX (10):

Instead of minimizing the surface sensitivity, some have

utilized the

deposition rate dependence of $\underbrace{\text{O.sub.3 /TEOS}}_{\text{Films}}$ films to perform gap fill for a

trenched silicon substrate wherein the side walls of the trench are covered

with thermal oxide spacers. Using an atmospheric pressure CVD (APCVD) **0.sub.3**

/TEOS deposition and an ozone concentration of 5%, it was reported that faster

film growth on the bottom silicon than on the side wall spacers precluded void

formation to achieve void-free gap fill. Others have investigated the

feasibility of forming a planarized intermetal dielectric (IMD) by taking

advantage of the surface sensitivity of **O.sub.3 /TEOS** and similar materials

such as O.sub.3 -octamethylcyclotetrasiloiane (OMTC). Researchers have

reported difficulties of controlling the different

deposition rates to achieve

planarity. For instance, significant elevations have been observed at the

edges of aluminum metal lines caused by the different deposition rates of the

O.sub.3 /TEOS on a TiN ARC layer on top of the aluminum and the aluminum side

walls. Some of these same researchers have reported more satisfactory

planarization results for depositing SiO.sub.2 layers on an aluminum

interconnect built upon a phosphorus glass (PSG) level using O.sub.3 -OMTC.

Brief Summary Text - BSTX (12):

What is needed are more efficient and economic methods for self-planarized

deposition of a high quality trench oxide filling layer for shallow trench

isolation integration. Improved methods of effectively utilizing the

deposition rate dependence of dielectric materials such as O.sub.3 /TEOS films
are also desired.

Brief Summary Text - BSTX (15):

One embodiment of the invention is directed to a method for forming a

dielectric layer on a silicon substrate which includes a silicon trench formed

between upper portions and having a trench bottom and a trench wall. The

substrate is disposed in a substrate processing chamber. The method uses a

precursor which provides deposition rate dependence of the dielectric layer on

differently constituted surfaces at different levels on the substrate. The

differently constituted surfaces at different levels include the trench bottom

and a material on the upper portions. The method includes the steps of

introducing the precursor, preferably **TEOS**, into the substrate processing

chamber and flowing **ozone** into the substrate processing chamber to react with

the precursor to deposit a dielectric layer over the substrate. An

ozone/precursor ratio between the ozone and the precursor is adjusted to

regulate deposition rates of the dielectric layer on the differently

constituted surfaces until the dielectric layer develops a substantially planar dielectric surface.

Detailed Description Text - DETX (10):

Compared with the conventional approach illustrated in FIGS. 1a-1d, the

method of FIG. 2a can eliminate the process of growing a thermal oxide over the

surfaces of the trench, which is conventionally used to repair the plasma

damage to the silicon substrate during trench formation. The inventors have

found that depositing the surface sensitive dielectric material such as **0.sub.3**

/TEOS directly over a silicon trench significantly improves the quality of the

trench fill layer to be formed over prior approaches and that the clean step

222 can further improve film quality, as discussed in more detail below. In